Tertiary Globigerinids from Kyushu, Japan

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(With 5 plates)

INTRODUCTION

In a previous paper titled "Some Paleogene Smaller Foraminifera from Japan", the writer discussed and described the smaller Foraminifera from the Paleogene formations of Kyushu. Since then, there have been published many papers on the planktonic Foraminifera, and at present no one denies that they form an excellent basis for precise regional and world-wide correlation in the Tertiary, as well as in the Cretaceous. And, for the reason, in this work the Tertiary Globigerinids of Kyushu are treated and compared with standards for such wide spread correlation.

Many Globigerinids samples have been found in the Eocene, Oligocene and Miocene formations of Kyushu, but some are deformed and thus the characters of the aperture which are most important in the Globigerinids classification are often incomplete. Moreover, the complex geology of Kyushu, and the intercalations of several nonmarine formations and incomplete surface sections, may not be an inviting ground for detailed biostratigraphic studies. This applies in particular to the Oligocene and Miocene sediments in various coal-fields of Northern Kyushu.

In this paper the writer only treats the paleontological results of the planktonic Foraminifera and their stratigraphic distribution in the Tertiary formations of Kyushu, of which world-wide correlation will be noted from the present knowledge of the fossils.

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EOCENE GLOBIGERINIDS FROM AMAKUSA ISLANDS, KYUSHU

According to the recent study of Murata, 1960, the Eocene sediments of the Amakusa Islands (Shimo-jima) comprise the following formations in descending order:

Sakasegawa group

- Oniike formation ····· Black gray massive shale intercalated with black gray hard sandstone and black gray shale, with abundant smaller Foraminifera, 500 m in thickness.
- Futae formation ····· An alternation of pale gray massive sandstone and black shale, with glauconite sandstone in the basal part; Foraminifera rare, 500 m in thickness.
- Sakasegawa formation ····· An alternation of gray massive sandstone and black shale in the upper part and grayish black massive shale with abundant smaller Foraminifera in the lower part, 450–1000 m in thickness.
- Itchoda formation ····· Dark green sandstone or sandy shale with glauconite and abundant mulluscan fossils (=*Crassatellites nipponicus* zone of Nagao, 1928), 5–10 m in thickness.

Shimo-jima group

Toishi formation ..... White arkose sandstone with some coal seams in the upper part and an alternation of black shale and fine grained sandstone in the lower part, 320–600 m in thickness.

Kyoragi formation ..... An alternation of black shale and fine grained sandstone with some smaller Foraminifera and molluscan fossils (=Tomiyama fossil beds of Hatae, 1960) in the upper part and black shale with abundant Foraminifera in the lower part, 700–1300 m in thickness.

Akashimisaki formation ..... Gray sandstone and conglomerate with intercalated gray shale with some smaller Foraminifera and molluscan fossils (=Lower *Orthaulax japonicus* zone of Nagao, 1928), together with calcareous sandstone lens containing *Nummulites*, *Discocyclina* etc. (=*Nummulites amakusensis-subamakusensis* zone of Nagao, 1928), 470–700 m in thickness.

..... unconformity .....

Cretaceous sediments and crystalline schists

The Eocene Globigerinids treated in the present paper are mainly from the Kyoragi, Sakasegawa and Oniike formations of Shimo-jima, Amakusa Islands, but some are from Kami-shima, where the lower group is well developed, but only parts of the upper group are exposed.

In the previous paper the writer reported on the occurrence of *Globorotalia* cf. *wilcoxensis* Cushman and Ponton, *Globorotalia bonairensis* Pijpers, *Globorotalia* sp., *Globigerina triloculinoides* Plummer, *Globigerina eocaenica* Terquem, *Globigerina kyushuensis* Asano and Murata and *Globigerina* sp. from the Kyoragi formation, and *Globigerina kyushuensis* Asano and Murata, *Globigerina* cf. *dissimilis* Cushman and Bermudez, *Globigerina* cf. *ouachitaensis senilis* Bandy, *Globigerina eocaenica* Terquem and *Globigerina* sp. from the Sakasegawa group.

The recent studies by various authors on the Globigerinids suggest that it is necessary to revise the specific identifications of our previously described materials and these are newly added in this work.

Brief accounts of the paleontological result are as follows:

In the lowest formation, Akashimisaki, only one species, *Globigerina* cf. *linaperta* Finlay is found, an accurate determination is difficult owing to the ill preservation of the material.

The Kyoragi formation, especially its lower shale member yielded a rich Globigerinids fauna at various localities of the Amakusa Islands. Its characteristic species are:

Globorotalia bullbrooki Bolli	Few
G. *centralis* Cushman and Bermudez	Few
G. cf. *pseudomayeri* Bolli	Few
G. spinuloinflata (Bandy)	Rare
G. bonairensis Pijpers	Rare
Globigerina linaperta Finlay	Few
G. kyushuensis Asano and Murata	Few
G. ariakensis Asano, n. sp.	Few
G. boweri Bolli	Few
G. cf. *yeguaensis* Weinzierl and Applin	Rare
Globoquadrina venezuelana (Hedberg)	Few

This assemblage is almost uniformly distributed in the shale member of the Kyoragi formation and is considered to be correlated with the *Hantkenina aragonensis-Globigerapsis*

kugleri zones (lower part of Navet formation) of Trinidad, established by Bolli in 1959 as the standard zonal sequence of the Tertiary and Cretaceous formations, although the representative species are different.

The shale members of the Sakasegawa group have also yielded a rich planktonic fauna. The characteristic species are:

Globigerina ampliapertura Bolli	Few
G. linaperta Finlay	Few
G. ouachitaensis senilis Bandy	Few
G. pera Todd	Rare
G. isahayensis Asano, n. sp.	Rare
Catapsydrax dissimilis (Cushman and Bermudez)	Rare
Globigerapsis cf. *kugleri* Bolli, Loeblich and Tappan.	Rare

This assemblage is widely found in the shale members of the Sakasegawa group and is quite distinguishable from that of the Kyoragi assemblage and may be correlated with the upper part of the Navet or San Fernando formation of Trinidad.

The middle part of the Navet formation of Trinidad is characterized with the *Porticulasphaera mexicana* zone and may be a correlative of the Toishi and Itchoda formations of Kyushu, from the stratigraphical order of succession of both areas, although no planktonic species have yet been found in these formations of Kyushu.

Recently Mr. Tsunemasa Saito found a characteristic planktonic assemblage correlative to the *Porticulasphaera mexicana* zone in the Hillsborough Islands (Hahajima) of the Ogasawara islands, Japan. Namely he has determined *Hantkenina dumblei* Weinzierl and Applin, *Globigerinatheka barri* Bronnimann, *Porticulasphaera mexicana* (Cushman), *Globorotalia lehneri* Cushman and Jarvis, *Globorotalia centralis* Gushman and Bermudez and *Truncorotaloides topilensis* (Cushman), together with abundant specimens of *Nummulites boninensis* Hanzawa.

Therefore, it is almost safely said that the Eocene Globigerinids faunas of the Navet formation of Trinidad also occur in Kyushu and Ogasawara Islands, Japan. This correlation clearly suggests that the *Nummulites amakusensis-subamakusensis* zone of Kyushu (belongs to Akashimisaki formation) is a considerably lower horizon than that of the *Nummulites boninensis* zone of Ogasawara islands.

OLIGOCENE AND MIOCENE GLOBIGERINIDS FROM NORTHERN KYUSHU

Oligocene and Miocene formations of Kyushu mostly consist of nonmarine sediments in the Takashima, Sakito-Matsushima, Karatsu and Chikuho coal-fields, but marine formations with planktonic fauna are intercalated in several horizons.

In the Iojima islands (Takashima coal-field) the Oligocene Iojima formation unconformably overlies the Eocene Okinoshima formation and both formations have yielded many characteristic benthonic Foraminifera as already reported by the writer.

From the lower part of the Iojima formation, just above the Dezaki conglomerate, the writer found the following planktonic Foraminifera; *Globigerina ampliapertura* Bolli, *Globoquadrina dehiscens* (Chapman, Parr and Collins) and *Globigerinoides* cf. *subquadratus* Bronnimann. This assemblage, according to the recent study of Jenkins in Australia is correlated with the *Globigerina ampliapertura* zone of Trinidad. Therefore the Iojima formation as a whole is considered to be Oligocene in age, including benthonic Foraminifera from the upper part (Funatsu shale member) of the formation.

In the Sakito-Matsushima coal-field, rich Globigerinids samples were collected by Murata from the Nakado formation of the Matsushima group, drilled at Sakito-machi, Nishisonogi-gun, Nagasaki Prefecture, by the Mitsubishi Coal Mining Company. Many authors consider that the Nakado formation is Oligocene in age from the stratigraphic order

and mega-fossils contained in it.

Individual numbers of Globigerinids from the Nakado formation are rather abundant, but they consist of only few species; namely

Globigerina sakitoensis Asano, n. sp.	Common
Globigerina cf. *trilocularia* d'Orbigny	Few
Globoquadrina venezuelana (Hedberg)	Few
Globigerinoides cf. *subquadratus* Bronnimann	Few

This assemblage does not contain the so-called guide species of the planktonic Foraminifera zone, but the most dominant species, *Globigerina sakitoensis* n. sp., has not yet been found in any Eocene or Miocene sediments in Kyushu and is considered to be a characteristic Oligocene species of Kyushu.

The Ashiya group of the Karatsu and Chikuho coal-fields have been discussed concerning its geological age by various authors. In the previous paper, the writer placed the Kishima formation of the basal part of the Ashiya group at the top of the Oligocene based upon the benthonic smaller Foraminifera. The Kishima formation of the Karatsu coal-field is well characterized by the Arita fossil beds (Nagao, 1928) which yielded abundant fossils of Mollusca and Foraminifera, but no planktonic species have been accurately determined. But from the boring core drilled at Takase, Imari City by the Sumitomo Coal Mining Company, the writer recently found well-preserved planktonic Foraminifera at depths between 555 and 582 m which stratigraphical position is just below the Arita fossil beds. They consist of the following species:

Catapsydrax dissimilis (Cushman and Bermudez)	Few
Globoquadrina dehiscens advena Bermudez	Few
Globigerinoides subquadratus Bronnimann	Few
Globigerinoides immaturus LeRoy	Few
Globigerina angustiumbilicata Bolli	Rare

This assemblage is considered to be correlated with the *Catapsydrax dissimilis-Catapsydrax stainforthi* zones of Trinidad which are placed at the lower part of the Aquitanian by Bolli.

In the Chikuho coal-field, Globigerinids were found from the Norimatsu shale of the Ashiya group. They comprise;

Globorotalia opima nana Bolli	Rare
Globorotaloides suteri Bolli	Rare
Globigerinoides muratae Asano, n. sp.	Few
Globigerinoides subquadratus Bronnimann	Rare
Globoquadrina venezuelana (Hedberg)	Rare
Globigerina cf. *trilocularis* d'Orbigny	Rare

These species were collected from two boring cores drilled at Shimuta, and Amasumi, Wakamatsu City, by the Nippon Coal Mining Company. This assemblage containing *Globorotalia opima nana* Bolli is apparently considered to be lower in horizon than that of Kishima formation of the Karatsu coal-field from the published records, but the most dominant species, *Globigerinoides muratae*, n. sp. and *Globigerinoides subquadratus* Bronnimann have somewhat younger aspects than those of Kishima from the view point of Globigerinids evolution. Tentatively the writer considers that the Norimatsu shale of the Ashiya group is situated in a somewhat younger geological age than that of the Kishima formation, but not so young as the *Globorotalia fohsi* zone of the Burdigalian age.

The sandy shale member developed at the top of the Ashiya group in the Karatsu coal-fields (Hatatsu formation, Nagao, 1928), has yielded some Globigerinids though not common, they consist of ;

Globigerina falconensis Blow	Few

Globoquadrina venezuelana (Hebderg) ..... Rare
Globigerina spp. ..... Rare

This assemblage seems to be younger than the typical Aquitanian assemblage and may belong to Burdigalian in age.

MATERIAL AND DESCRIPTION OF THE EOCENE SPECIES

Eocene Globigerinids materials here treated were collected from more than ten localities of the Kyoragi and Sakasegawa formations, they are;

1 km west of Kanyama, Kawaura-machi (formerly Itchoda-mura), Shimo-jima; Lower part of the Kyoragi formation. This locality yielded the largest number of specimens and many species, viz.,

Globigerina ariakensis Asano, n. sp. ..... Rare
G. boweri Bolli ..... Few
G. kyushuensis Asano and Murata ..... Few
G. linaperta Finlay ..... Common
G. cf. *trilocularis* d'Orbigny ..... Rare
Globorotalia bonairensis Pijpers ..... Rare
G. bullbrooki Bolli ..... Few
G. centralis Cushman and Bermudez ..... Few
G. spinuloinflata (Bandy) ..... Rare
G. sp. ..... Rare
Globoquadrina venezuelana (Hedberg) ..... Few

500 m west of Okubo, Ariake-mura, Kami-shima; Lower part of the Kyoragi formation.

Globigerina ariakensis Asano, n. sp. ..... Common
G. cf. *linaperta* Finlay ..... Few
G. spp. ..... Few
Globorotalia cf. *pseudomayeri* Bolli ..... Few
Globoquadrina venezuelana (Hedberg) ..... Few

500 m north of Hirakida, Akasaki-mura, Kami-shima; Lower part of the Kyoragi formation.

Globigerina ariakensis Asano, n. sp. ..... Rare
G. boweri Bolli ..... Rare
G. kyushuensis Asano and Murata ..... Rare
Globorotalia bonairensis Pijpers ..... Rare
G. centralis Cushman and Bermudez ..... Rare
Globoquadrina cf. *venezuelana* (Hedberg) ..... Few
Globigerinatheka sp. ..... Rare

1 km northwest of Yamaura, Ariake-mura, Kami-shima; Lower part of the Kyoragi formation.

Globigerina kyushuensis Asano and Murata ..... Few
G. linaperta Finlay ..... Few
G. sp. ..... Rare

Hashira-matsu, Sumoto-machi, Kami-shima; Lower part of the Kyoragi formation.

Globigerina linaperta Finlay ..... Rare

Boring core at depths between 61 and 80 m, drilled at Kamihara, Enoura-mura, Kitatakaki-gun, Nagasaki Prefecture; Enoura formation (correlated with the upper part of the Kyoragi formation).

Globigerina isahayensis Asano, n. sp. ..... Few
G. linaperta Finlay ..... Rare
Globoquadrina venezuelana (Hedberg) ..... Few

Several localities at Shimo-jima belonging to the upper part of the Kyoragi formation. These localities yielded such as *Globigerina linaperta* Finlay and *Globoquadrina venezuelana* (Hedberg), but very rarely.

About 200 m west of Ichikogi, Miyachidake-mura, Shimo-jima; Lower part of the Sakasegawa formation.

Globigerina linaperta Finlay ..... Rare
G. ouachitaensis senilis Bandy ..... Rare
G. sp. ..... Rare

1 km northwest of Ichikogi, Miyachidake-mura, Shimo-jima; Lower part of the Sakasegawa formation.

Globigerina linaperta Finlay ..... Rare

About 500 m west of Hikisaka, Gowa-machi (formerly Oninoike-mura), Shimo-jima; Oniike formation (formerly referred to the upper part of the Sakasegawa shale).

Globigerina ampliapertura Bolli ..... Few
G. cf. *linaperta* Finlay ..... Rare
G. cf. *trilocularis* d'Orbigny ..... Rare
Globoquadrina venezuelana (Hedberg) ..... Rare
Globigerapsis cf. *kugleri* Bolli ..... Rare
Catapsydrax dissimilis (Cushman and Bermudez) ..... Few

Oshima, Gowa-machi, Shimo-jima; Oniike formation.

Globigerina ampliapertura Bolli ..... Rare
G. linaperta Finlay ..... Rare
G. ouachitaensis senilis Bandy ..... Rare
G. cf. *pera* Todd ..... Rare
Globoquadrina venezuelana (Hedberg) ..... Rare

About 1 km northeast of Sakasegawa-mura, Shimo-jima; Oniike formation.

Globigerina linaperta Finlay ..... Few
G. cf. *pera* Todd ..... Rare
Globoquadrina venezuelana (Hedberg) ..... Few
Catapsydrax dissimilis (Cushman and Bermudez) ..... Rare

About 500 m east of Hikisaka, Gowa-machi, Shimo-jima; Oniike formation.

Globigerina cf. *linaperta* Finlay ..... Few
G. ouachitaensis senilis Bandy ..... Few
G. isahayensis Asano, n. sp. ..... Rare

Horikawa, Yamaguchi village, Kazusa-machi, Minami-Takaki-gun, Nagasaki Prefecture; formation unnamed, but correlated with Oniike formation by S. Murata.

Globigerina ampliapertura Bolli ..... Few
G. isahayensis Asano, n. sp. ..... Rare
G. linaperta Finlay ..... Few
G. ouachitaensis senilis Bandy ..... Few
G. cf. *sakitoensis* Asano, n. sp. ..... Few
Globoquadrina venezuelana (Hedberg) ..... Few

Genus ***Globigerina*** d'Orbigny, 1826

Globigerina ampliapertura Bolli

Pl. 21, figs. 4a, b.

Globigerina ampliapertura Bolli, 1957b, p. 108, pl. 22, figs. 4–7; 1957c, p. 164, pl. 36, figs. 8a–c.

Hypotype : – About 500 m west of Hikisaka, Gowa-machi, Shimo-jima; Sakasegawa formation; IGPS coll. cat. no. 77222.

Remarks : – This species differs from *Globigerina apertura* Cushman in having a smaller

aperture in comparison with the chamber size.
Occurrence : – Common in the Sakasegawa formation, but unknown from the Kyoragi formation.

Globigerina ariakensis Asano, n. sp.
Pl. 20, figs. 5a, b, c; 7a, b, c.

Test moderately trochospiral, periphery broadly rounded, somewhat lobulated; chambers inflated, usually four in last whorl, arranged in a lozenge on umbilical side; wall finely perforate, surface smooth; sutures depressed, but indistinct on spiral side, nearly radial on umbilical side; umbilicus depressed, almost closed; aperture elongate, without a lip.

Maximum diameter of holotype 1.0 mm.
Holotype : – Figs. 7a, b, c, 500 m west of Okubo, Ariake-mura, Kami-shima; Kyoragi formation; IGPS coll. cat. no. 77223.
Remarks : – This new species appears to be related to *Globoquadrina venezuelana* (Hedberg), but is clearly distinguished from it by the characters of the aperture.
Occurrence : – Restricted to the lower part of the Kyoragi formation, Amakusa Islands.

Globigerina boweri Bolli
Pl. 19, figs. 1a, b.

Globigerina boweri Bolli, 1957c, p. 163, pl. 36, figs. 1, 2.

Hypotype : – 1 km west of Kanyama, Kawaura-machi, Shimo-jima ; Kyoragi formation ; IGPS coll. cat. no. 77224.
Remarks :– A comparatively higher arched aperture which has a tendency to be slightly extraumbilical in position is characteristic of this species.
Occurrence : – A few specimens have been found in the lower part of the Kyoragi formation at several localities in the Amakusa Islands. It is noticeable that a form very similar to the hypotype occurs rarely in the lower part of the Kattachi formation of the Ariake district, Kumamoto Prefecture.

Globigerina isahayensis Asano, n. sp.
Pl. 21, figs. 9a, b, c,

Test trochospiral, low-spired, periphery rounded ; four chambers in last whorl, of which last one is very small and attached on peripheral side ; sutures depressed, slightly curved ; wall calcareous, finely perforate ; aperture at umbilical end of last formed chamber, with a small lip ; umbilicus not covered by any bulla.

Maximum diameter of holotype 0.4 mm.
Holotype : – From 80 m depth of the boring core at Kamihara, Enoura-mura, Kita-Takaki-gun, Nagasaki Prefecture ; Enoura formation, correlative with the upper part of the Kyoragi formation ; IGPS coll. cat. no. 77225.
Remarks :– This new species is apparently similar to *Catapsydrax unicavus* Bolli, Loeblich and Tappan, but is distinguished from it by the much smaller last chamber, instead of a bulla. In this respect, it is somewhat related to *Catapsydrax unicavus* Blow (not Bolli, Loeblich and Tappan), but differs in the number of chambers of the last whorl.
Occurrence :– From the upper part of the Kyoragi formation to the top of the Sakasegawa group.

Globigerina kyushuensis Asano and Murata
Pl. 20, figs. 1a, b, c; 2a, b, c.

Globigerina kyushuensis Asano and Murata, 1958, p. 68, pl. 12, figs. 1a–c.

Hypotype :– 1 km west of Kanyama, Kawaura-machi, Shimo-jima ; Kyoragi formation ; IGPS coll. cat. no. 77226.

Remarks :– This species is distinguished from *Globigerina ampliapertura* Bolli which seems to be a descendant of this species by the narrower aperture. But intermediate forms showing the aperture to be transitional from one to the other occur in the upper part of the Kyoragi and lower part of the Sakasegawa formations.

Occurrence :– Typical forms occur only in the Kyoragi formation, but forms transitional to *Globigerina ampliapertura* Bolli are observed in the Sakasegawa formation.

Globigerina linaperta Finlay
Pl. 19, figs. 7a, b, c ; 8a, b ; Pl. 21, figs. 1a, b.

Globigerina linaperta Finlay, 1936, p. 125, pl. 13, figs. 54–57; Bronnimann, 1952, pl. 2, figs. 7–9; Bolli, 1957a, p. 70, pl. 15, figs. 15–17; 1957c, p. 163, pl. 36, figs. 5a–b.
Globigerina eocaenica Asano, 1958, p. 62, pl. 12, figs. 2a, b.

Hypotype :– 500 m west of Okubo, Ariake-mura, Kami-shima ; Kyoragi formation ; IGPS coll. cat. no. 77227 ; 1 km west of Kanyama, Kawaura-machi, Shimo-jima, Kyoragi formation ; IGPS coll. cat. no. 77228 ; Oshima, Gowa-machi, Shimo-jima ; Oniike formation ; IGPS coll. cat. no. 77252.

Remarks :– Bolli says that *Globigerina linaperta* Finlay is probably a descendant of *G. triloculinoides* Plummer from which it is distinguished by its larger size and less distinct flaring lip protecting the aperture. Our specimens show considerable variation in the grade of perforation and outline of the test. Fig. 8 on Plate 21 may be closely related to *Globigerina triloculinoides* Plummer.

Occurrence :– This long ranged Eocene species occurs commonly in many localities of the Kyoragi and Sakasegawa groups, but none are known from the overlying formations.

Globigerina ouachitaensis senilis Bandy
Pl. 21, figs. 5a, b.

Globigerina ouachitaensis senilis Bandy, 1949, p. 121, pl. 22, figs. 5a–c.
Globigerina cf. *ouachitaensis senilis* Asano, 1958, p. 62, pl. 12, figs. 8, 10.

Hypotype :– Oshima, Gowa-machi, Shimo-jima ; Oniike formation ; IGPS coll. cat. no. 77229.

Remarks :– This species is usually smaller in size than *Globigerina ariakensis* Asano, n. sp. of which periphery is much rounded.

Occurrence :– Commonly observed in the Sakasegawa group, but none occurs from the Kyoragi formation.

Globigerina cf. ***pera*** Todd
Pl. 21, figs. 6a, b.

Globigerina pera Todd, 1957, p. 301, pl. 70, figs. 10, 11.

Hypotype : – Oshima, Gowa-machi, Shimo-jima ; Oniike formation; IGPS coll cat. no. 77230.

Remarks :– Our specimens resemble Todd's species in having a pocketlike supplementary chamber, but I cannot determine exactly whether this similarity is superficial or structural owing to the ill preservation.

Globigerina cf. ***trilocularis*** d'Orbigny
Pl. 20, figs. 4a, b.

Globigerina triloculinoides Asano, 1958, p. 63, figs. 3a, b.

Globigerina triloculinoides Asano, 1958, p. 63, figs. 3a, b.
Hypotype :– 1 km west of Kanyama, Kawaura-machi, Shimo-jima ; Kyoragi formation ; IGPS coll. cat. no. 77231.
Remarks :– The outline of the test of our specimens rather resemble *G. triloculinoides* Plummer, but the characters of the aperture without a flaplike lip differ from it and appear to be closer to *Globigerina trilocularis* d'Orbigny. A very similar form was recorded from the Eocene San Fernand formation of Trinidad under the name of *G.* cf. *trilocularis* d' Orbigny by Bolli, 1957 b.
Occurrence :– Occasionally found in samples isolated from the Kyoragi and Sakasegawa groups.

Globigerina sp. (***G.*** cf. ***yeguaeusis*** Weinzierl and Applin)
Pl. 21, figs. 2a, b.

Test distinctly lobate ; sutures much depressed ; umbilicus fairly open and a distinct apertural lip present.
Remarks :– The stated characters resemble *G. yeguaensis,* especially one of Bolli's figures (1957c, p. 163, pl. 35, fig. 15 (not 14), 1957), but the insufficient material at hand does not permit complete description and naming.
Hypotype :– 1 km east of Kyoragi, Matsushima-machi, Kamishima ; Kyoragi formation ; IGPS coll. cat. no. 77232.
Occurrence :– A form very similar to the present specimen here figured also occurs from the Oniike formation, although very rarely.

Genus ***Globorotalia*** Cushman, 1927

Globorotalia centralis Cushman and Bermudez
Pl. 19, figs. 3a, b, c.

Globorotalia centralis Cushman and Bermudez, 1937, p. 26, pl. 2, figs. 62–65; Bermudez, 1949, p. 284, pl. 22, figs. 30–32; Todd, 1957, pl. 71, figs. 1, 3; Bolli, 1957c, p. 169, pl. 39, figs. 1–4.
Globorotalia cf. *wilcoxensis* Asano, 1958, p. 63, pl. 12, figs. 4a–c.

Hypotype : – 1 km west of Kanyama, Kawaura-machi, Shimo-jima ; Kyoragi formation ; IGPS coll. cat. no. 77233.
Remarks ;– According to Bolli, during the evolution of the species there is a change in chamber shape from rounded towards subangular. Our specimens here figured closely resembles Bermudez's specimens from the Dominican Republic.
Occurrence :– Fairly common in the Kyoragi formation, but none found from the Sakasegawa group.

Globorotalia bonairensis Pijpers
Pl. 19, figs. 4a, b, c.

Globorotalia bonairensis Pijpers, 1933, p. 71, text-figs. 107–110; Asano, 1958, p. 63, pl. 12, figs. 5a–c.

Hypotype :– 1 km west of Kanyama, Kawaura-machi, Shimo-jima ; Kyoragi formation ; IGPS coll. cat. no. 77234.
Remarks :– This species is distinguished from *Globorotalia centralis* Cushman and Bermudez by the deeply excavated umbilicus.
Occurrence :– Only found from the Kyoragi formation.

Globorotalia bullbrooki Bolli
Pl. 19, figs. 5a, b, c.

Globorotalia bullbrooki Bolli, 1957c, p. 167, pl. 38, figs. 4–5.

Hypotype : – 1 km west of Kanyama, Kawaura-machi, Shimo-jima ; Kyoragi formation ; IGPS coll. cat. no. 77235.
Remarks :– This characteristic species with four subangular chambers in the last whorl may be distinguished from *Globorotalia bonairensis* Pijpers by the rapidly increased chambers of the last whorl.
Occurrence :– Restricted to the lower part of the Kyoragi formation.

Globorotalia spinuloinflata (Bandy)
Pl. 19, figs. 6a, b.

Globigerina spinuloinflata Bandy, 1949, p. 122, pl. 23, figs. 1a-c.
Globorotalia spinuloinflata Bolli, 1957c, p. 168, pl. 38, figs. 8a-c.

Hypotype :– 1 km west of Kanyama, Kawaura-machi, Shimo-jima ; Kyoragi formation : IGPS coll. cat. no. 77236.
Remarks :– This species is distinguished from *Globorotalia bullbrooki* Bolli by the larger number of chambers in the last whorl.
Occurrence :– Restricted to the lower part of the Kyoragi formation.

Globorotalia cf. ***pseudomayeri*** Bolli
Pl. 20, figs. 3a, b, c.

Globorotalia pseudomayeri Bolli, 1957c, p. 167, pl. 37, figs. 17a-c.

Hypotype :– 500 m west of Okubo, Ariake-mura, Kami-shima ; Kyoragi formation ; IGPS coll. cat. no. 77237.
Remarks :– The present specimens attaining 0.7 mm in maximum diameter are usually larger than Bolli's specimens, but are similar in the low trochospiral test and number of chambers in the last whorl. The apertural characters of our specimens are indistinct.
Occurrence :– Restricted to the lower part of the Kyoragi formation.

Globorotalia sp.
Pl. 19, figs. 2a, b, c.

Test much compressed, low trochospiral, periphery rounded, composed of four chambers in the last whorl ; sutures nearly radial on the umbilical side ; umbilicus narrow ; aperture indistinct.
Hypotype :– 1 km west of Kanyama, Kawaura-machi, Shimo-jima ; Kyoragi formation : IGPS coll. cat. no. 77238.
Remarks :– The single specimen here figured is probably either abnormal or a compressed species of *Globorotalia centralis* Cushman and Bermudez.
Occurrence :– Very rare in the Kyoragi formation.

Genus ***Globoquadrina*** Finlay, 1947

Globoquadrina venezuelana (Hedberg)
Pl. 20, figs, 6a, b, c.

Globigerina venezuelana Hedberg, 1937, p. 681, pl. 92, figs. 7a, b; Cushman and Stainforth, 1945, p. 67, pl. 12, figs. 13a, b; Bermudez, 1949, p, 280, pl. 21, figs. 39-40; Bolli 1957b, p. 110, pl. 23, figs. 6–8; 1957c, p. 164, pl. 35, figs. 16–17.
Globorotalia sp. Asano, 1958, p. 63, pl. 12, figs. 6a, b.
Globoquadrina venezuelana Blow, 1959, p. 186, pl. 11, figs. 58a-c.

Hypotype :- 1 km west of Kanyama, Kawaura-machi, Shimo-jima ; Kyoragi formation : IGPS coll. cat. no. 77239.
Remarks :- This long ranged species shows a wide range in variation in size and shape of chambers in our material, as already discussed by Bolli and Blow.
Occurrence :- Throughout the Kyoragi formation to the Sakasegawa group.

Genus ***Globigerapsis*** Bolli, Loeblich and Tappan, 1957

Globigerapsis cf. ***kugleri*** Bolli, Loeblich and Tappan
Pl. 21, figs. 3a, b.

Globigerapsis kugleri Bolli, Loeblich and Tappan, 1957, p. 34, pl. 6, figs. 6a, b; Bolli, 1957c, p. 165, pl. 36, figs. 21a, b.

Hypotype :- About 500 m west of Hikisaka, Gowa-machi, Shimo-jima ; Oniike formation ; IGPS coll. cat. no. 77240.
Remarks :- Except for the spiral side, the present specimen, here figured, resembles the species described by Bolli, Loeblich and Tappan, but the supplementary apertures are much smaller and the chambers less inflated.
Occurrence :- Observed only in the locality above cited.

Genus ***Globigerinatheka*** Bronnimann, 1952

Globigerinatheka sp.
Pl. 21, fig. 10.

Hypotype :- 1 km northwest of Yamaura, Ariake-mura, Kami-shima, Kyoragi formation ; IGPS coll. cat. no. 77241.
Remarks :- This distinctly subglobose species apparently differs from any described species of *Globigerinatheka*, but the insufficient material at hand does not permit complete description, owing to the ill preservation of the spiral side.
Occurrence :- Rarely at the only one locality above cited.

MATERIAL AND DESCRIPTION OF OLIGOCENE AND MIOCENE SPECIES

The Oligocene and Miocene Globigerinids materials, as already stated in the previous chapter, were found only in the following boring cores ;

The boring core from depths between 101 and 126 m, drilled at Nakado, Sakito-machi, Nishisonogi-gun, Nagasaki Prefecture ; Nakado formation.

Depth 101 m :	*Globigerina* cf. *trilocularis* d'Orbigny	Rare
	Globigerina sp.	Rare
114 m :	*Globigerina* cf. *trilocularis* d'Orbigny	Rare
	Globigerina sp.	Rare
119 m :	*Globigerina* spp.	Rare
126 m :	*Globigerina sakitoensis* Asano, n. sp.	Few
	Globigerinoides cf. *subquadratus* Bronnimann	Few
	Globoquadrina venezuelana (Hedberg)	Few
	Globigerina cf. *trilocularis* d'Orbigny	Rare

The boring core from the lower part of the Iojima formation, just above the Dezaki conglomerate, drilled at Dezaki, Okinoshima, Nagasaki Prefecture ; Iojima formation.

Globigerina ampliapertura Bolli	Rare
G. cf. *trilocularis* d'Orbigny	Rare
Globigerinoides cf. *subquadratus* Bronnimann	Rare
Globoquadrina dehiscens (Chapman, Parr and Collins)	Rare

The boring core from depths between 555–582 m (just below the Arita fossil beds), drilled at Takase, Imari City ; Kishima formation.

Globigerina angustiumbilicata Bolli ..... Rare
Globigerinoides immaturus LeRoy ..... Few
G. subquadratus Bronnimann ..... Few
Globoquadrina dehiscens advena Bermudez ..... Few
Catapsydrax dissimilis (Cushman and Bermudez) ..... Few

The boring core from depths between 170–220 m drilled at Amasumi, Wakamatsu City; Norimatsu shale.

Globigerina sp. ..... Rare
Globigerinoides muratae Asano, n. sp. ..... Rare
G. subquadratus Bronnimann ..... Rare
Globoquadrina venezuelana (Hedberg) ..... Rare
Globorotalia opima nana Bolli ..... Rare

The boring core from depths between 70–90 m, drilled at Shimuta, Ashiya-machi, Wakamatsu City; Norimatsu shale.

Globigerina cf. *trilocularis* d'Orbigny ..... Rare
G. sp. ..... Rare
Globigerinoides muratae Asano, n. sp. ..... Few
Globorotaloides suteri Bolli ..... Rare

Genus ***Globigerina*** d'Orbigny, 1826

Globigerina angustiumbilicata Bolli

Pl. 23, figs. 3a, b.

Globigerina ciperoensis angustiumbilicata Bolli, 1957b, p. 109, pl. 22, figs. 12, 13; 1957c, p. 164, pl. 36, figs. 6a, b.
Globigerina angustiumbilicata Blow, 1959, p. 172, pl. 7, figs. 33, 34; Jenkins, 1960, p. 350, pl. 1, figs. 2a-c.

Hypotype: – 555 m depth of the boring core at Takase, Imari City; Kishima formation; IGPS coll. cat. no. 77242.
Remarks: – According to published records there are some variations in the characters of the umbilicus. Our specimens, as here figured, are very similar to the one reported by Bolli from the Cipero formation, Trinidad.

Globigerina sakitoensis Asano, n. sp.

Pl. 22, figs. 1a, b, c.

Test large, subquadrate in outline, low-spired, periphery broadly rounded; chambers few, large and inflated, later ones strongly embracing dorsally and overhanging the umbilicus ventrally, last three constituting most of the test; sutures indistinct on dorsal side, depressed and gently curved on ventral side; umbilicus narrow, deep; wall finely perforate; aperture narrow, often with a small lip.

Maximum diameter 0.8 mm, thickness 0.5 mm.
Holotype: – 126 m depth of the boring core drilled at Nakado, Sakito-machi, Nishisonogi-gun, Nagasaki Prefecture; Nakado formation; IGPS coll. cat. no. 77243.
Remarks: – This species is distinguished from *Globigerina eximia* Todd by the subquadrate test and not lobulate chambers.
Occurrence: – Restricted to the Nakado formation, Nagasaki Prefecture. Similar forms (Pl. 22, figs. 2a–c) although not strongly embracing dorsally were found in the samples from Yamaguchi, Kazusa-machi, Minami-takaki-gun, Nagasaki Prefecture.

Genus ***Catapsydrax*** Bolli, Loeblich and Tappan, 1957

Catapsydrax dissimilis (Cushman and Bermudez)
Pl. 23, figs. 4a, b.

Globigerina dissimilis Cushman and Bermudez, 1937, p. 25, pl. 3, figs. 4-6; Bermudez, 1949, p. 279, pl. 21, fig. 47.
Catapsydrax dissimilis Bolli, Loeblich and Tappan, 1957, p. 36, pl. 7, figs. 6–8; Blow, 1959, p. 203, pl. 12, figs. 88–90.
Globigerina (?) *dissimilis* Asano, 1958, p. 62, pl. 12, figs. 9a, b.

Hypotype :– 555 m depth of the boring core at Takase, Imari City ; Kishima formation ; IGPS coll. cat. no. 77244.
Remarks :– Our specimens in having indistinct infralaminal apertures are not typical, but are covered with the bulla.
Occurrence :– Observed only in the Kishima formation of the Karatsu Coal-fields.

Genus ***Globoquadrina*** Finlay, 1947

Globoquadrina dehiscens (Chapman, Parr and Collins)
Pl. 22, figs. 4a, b.

Globorotalia dehiscens Chapman, Parr and Collins, 1934, p. 569, pl. 11, figs. 36a-c; Bolli (part), 1957b, p. 111, pl. 24, figs. 3a-c (not figs. 4a-c); Todd, 1957, p. 279, pl. 79, figs. 12a-c;
Globoquadrina dehiscens dehiscens Blow, 1959, p. 182, pl. 8, figs. 49-c; Jenkins, 1960, p. 354, pl. 3, figs. 3a-c.

Hypotype :– Boring core at Dezaki, Okinoshima ; Iojima formation ; IGPS coll. cat. no. 77245.
Remarks :– Our specimens show much lateral compression, with a quadrate outline of test, which is one of the characters of this species, but the umbilical teeth are indistinct.
Occurrence : – Restricted to the lower part of the Iojima formation.

Globoquadrina dehiscens advena Bermudez
Pl. 22, figs. 5a, b, c.

Globoquadrina quadraria var. *advena* Bermudez, 1949, p. 287, pl. 22, figs. 36–38; Blow, 1959, p. 182, pl. 8, figs. 50a-b; Jenkins, 1960, p. 355, pl. 3, figs. 4a–c.

Hypotype :– 580 m depth of the boring core at Takase, Imari City ; Kishima formation ; IGPS coll. cat. no. 77246.
Remarks :– Our specimens are very close to the type figures of this species.
Occurrence :– Restricted to the Kishima formation.

Genus ***Globigerinoides*** Cushman, 1927

Globigerinodies immaturus LeRoy
Pl. 23, figs. 2a, b.

Globigerinoides sacculiferus var *immatura* LeRoy, 1939, p. 263, pl. 3, figs. 19-21.
Globigerinoides triloba immatura Bolli, 1957b, p. 113, pl. 25, figs. 3-4; Blow, p. 188, pl. 11. figs. 62a, b.
Globigerinoides quadrilobatus immaturus Banner and Blow, 1960, p. 17-19.

Hypotype :– 575 m depth of the boring core at Takase, Imari City ; Kishima formation ; IGPS coll. cat. no. 77247.
Remarks :– As already discussed by Bolli, Banner and Blow, it is clear that the present form is closely related to *G. sacculiferus* or *trilobus*, but it may be premature to include this into *Globigerinoides quadrilobatus* group, because many other related forms are retained

in specific rank.
Occurrence:– Only found in the Kishima formation in the treated material.

Globigerinoides muratae Asano, n. sp.
Pl. 23, figs. 7a, b, c.

Test low, trochospiral with four chambers in last whorl, periphery rounded, quadrilobate equatorially; chambers inflated, arranged in 2–3 whorls; sutures depressed, gently curved; wall rather finely perforated; umbilicus large; primary aperture a medium-sized arch, interiomarginal, umbilical, with a clear lip, one or two supplementary sutural apertures are visible in last few chambers.

Maximum diameter of holotype 0.5 mm.
Holotype:– From 80 m depth of the boring core at Shimuta, Wakamatsu City; Norimatsu shale; IGPS coll. cat. no. 77248 .
Remarks:– This species is distinguished from its allied ones by the low trochospiral and typically quadrilobate outline of the test.
Occurrence:– Occasionally found from the Norimatsu shale of the Chikuho Coal-fields.

Globigerinoides subquadratus Bronnimann
Pl. 23, figs. 1a, b.

Globigerinoides subquadrata Bronnimann, 1954, in Todd, Cloud, Low and Schmidt, p. 680, pl. 1, figs. 5, 8; Todd, 1957, p. 303, pl. 74, fig. 6.
Globigerinoides rubra Bolli (part), 1957b, p. 113; Blow (part), 1959, p. 192.
Globigerinoides ruber subquadratus Banner and Blow, 1960, pp. 19-21.

Hypotype:– 555 m depth of the boring core at Takase, Imari City; Kishima formation; IGPS coll. cat. no. 77249.
Remarks:– So far as the Japanese specimens are concerned, this species is clearly distinguished from *Globigerinoides ruber* (d' Orbigny) by the subquadrate outline of the test.
Occurrence:– The Nakado, Kishima and Norimatsu formations.

Genus ***Globorotalia*** Cushman, 1927

Globorotalia opima nana Bolli
Pl. 23, figs. 5a, b, c.

Globorotalia opima nana Bolli, 1957b, p. 118, pl. 28, figs. 3a-c.

Hypotype:– 220 m depth of the boring core at Amasumi, Wakamatsu City; Norimatsu shale; IGPS coll. cat. no. 77250.
Remarks:– This species differs from *Globorotalia mayeri* Cushman and Ellisor by the greater relative thickness of the test and by having 4–5 chambers in the last whorl, instead of 5–6.
Occurrence:– Found only from the Norimatsu shale.

Genus ***Globorotaloides*** Bolli, 1957

Globorotaloides suteri Bolli
Pl. 23, figs. 8a, b, c.

Globorotaloides suteri Bolli, 1956b, p. 117, pl. 27, figs. 9–13.

Hypotype:– 80 m depth of the boring core at Shimuta, Wakamatsu City; Norimatsu shale; IGPS coll. cat. no. 77251.
Remarks:– It is often difficult to determine this species because during ontogenetic development it acquires different characters of three different planktonic genera and therefore, discrimination of their young stages is confusing. However, our specimen shows the *Globorotalia* stage and is very close to one of the figures of Bolli (Pl. 27, figs. 10a, b.).

REFERENCES

Akers, W. H., 1955, Some planktonic Foraminifera of the American Gulf Coast and suggested correlation with the Caribbean Tertiary. *Jour. Pal.*, 29 (4), p. 647–664, pl. 65, text-figs. 1–3.

Akers, W. H. and Drooger, C. W., 1957, Miogypsinids, planktonic Foraminifera and Gulf Coast Oligo-Miocene correlations. *Amer. Assoc. Petr, Geol., Bull.*, 41 (4), p. 656–678, text-figs. 1–2.

Asano, K., 1958, Some Paleogene smaller Foraminifera from Japan. *Tohoku Univ., Sci. Rep., 2nd Ser. (Geol.).*, 29, p. 43–75, pls. 8–13, text-figs. 1–12.

Asano, K. and Murata, S., 1956, Paleogene Foraminifera from Okinoshima and Iojima, Nagasaki Prefecture (in Japanese). *Foraminifera*, (5), p. 39–43.

————, 1957, Eocene Foraminifera from Amakusa Islands, Kyushu (in Japanese). *Foraminifera*, (7), p. 23–27.

————, 1957, Paleogene Foraminifera from the Ashiya Group, Kyushu (in Japanese). *Foraminifera*, (7), p. 28–31.

Bandy, O. L., 1944, Eocene Foraminifera from Cape Blanco, Oregon, *Jour. Pal.*, 18, p. 366–377, pls. 60–62.

————, 1949, Eocene and Oligocene Foraminifera from Little Stave Creek, Clarke County, Alabama. *Amer. Pal., Bull.* 32 (131), p. 1–210, pls. 1–27.

Banner, F. T. and Blow, W. H., 1959, The classification and stratigraphical distribution of the Globigerinaceae, pt. 1, *Pal.*, 2 (1), p. 1–27, pls. 1–3, text-figs. 1–5.

———— 1960, Some primary types of species belonging to the Superfamily Globigerinaceae. *Cushman Found. Foram. Res., Contr.* 11 (1), p. 1–14, pls. 1–18, text-figs. 1, 2.

Beckmann, J. P., 1953, Die Forminiferen der Oceanic Foramation (Eocaen-Oligocaen) von Barbados, Kl. Antillen. *Ecl. Geol. Helv.*, 46 (2), p. 301–412, pls. 16–30, text-figs. 1–29, table 1.

Berggren, W. A., 1960, Some planktonic Foraminifera from the Lower Eocene of Denmark and Northwestern Germany. *Acta Univ. Stockholmiensis, Stockholm Contr. Geol.*, 5 (3), p. 41–108, pls. 1–13, text-figs. 1–13.

————, 1960, Paleogene biostratigraphy and planktonic Foraminifera of the SW Soviet Union, An analysis of recent Soviet Investigations. *Ibid.*, 6 (5), p. 63–125, tables. 1–7.

Bermudez, P. J., 1949, Tertiary smaller Foraminifera of the Dominican Republic. *Cushman Lab. Foram. Res., Spec. Publ.* 25, p. 1–322, pls. 1–26.

————, 1952, Estudio Sistematico de los Foraminiferos, Rotaliformes. *Bol. Geol., Min. Minas Hidroc.*, 2 (4), p. 1–230, pls. 1–35.

Blow, W. H., 1957, Trans-Atlantic correlation of Miocene sediments. *Micropal.*, 3 (1), p. 77–79.

————, 1959, Age, correlation and biostratigraphy of the Upper Tocuyo (San Lorenzo) and Pozon Formations, Eastern Falcon, Venezuela. *Bull., Amer. Pal.*, 39 (178), p. 1–251, pls. 1–19, text-figs. 1–5.

Bolli, H. M., 1957a, The genera *Globigerina* and *Globorotalia* in the Paleocene-Lower Eocene Lizard Springs formation of Trinidad, B. W. I., *U. S. Nat. Mus., Bull.*, 215, p. 61–81, pls. 15–20, text-figs. 12, 13.

————, 1957b, Planktonic Foraminifera from the Oligocene-Miocene Cipero and Lengua Formations of Trinidad, B.W.I., *Ibid.*, 215, p. 97–123, pls. 22–29, text-figs. 17–21.

————, 1957c, Planktonic Foraminifera from the Eocene Navet and San Fernando Formations of Trinidad, B. W. I., *Ibid.*, p. 155–172, pls. 35–39, text-figs. 25–26.

————, 1959, Planktonic Foraminifera as index fossils in Trinidad, West Indies and their value for worldwide stratigraphic correlation. *Ecl. Geol. Helv.*, 52 (2), p. 627–637, table 1.

Bolli, H. M., Loeblich, A. R. and Tappan, H., 1957, Planktonic Foraminiferal Family Hantkeninidae, Orbulinidae, Globorotaliidae and Globotruncanidae, *U. S. Nat. Mus., Bull.*, 215, p. 3–50, pls. 1–11, text-figs. 1–9.

Bronnimann, P., 1951, The genus *Orbulina* d'Orbigny in the Oligocene-Miocene of Trinidad, B. W. I. *Cushman Found. Foram. Res., Contr.*, 2 (4), p. 132–138, text-figs. 1–4.

———— 1952, Trinidad Paleocene and Lower Eocene Globigerinidae. *Bull. Ameri. Pal.*, 34 (143), p. 1–34, pls. 1–3.

Bronnimann, P. and Todd, R., 1954, In an appendix to Todd, R., Cloud, P. E., Low, D. and Schmidt, R. G., Probable occurrence of Oligocene on Saipan. *Amer. Jour. Sci.*, 252 (11), pp. 673–682, pl. 1.

Brotzen, F., 1948, The Swedish Paleocene and its Foraminiferal fauna. *Sver. Geol. Unders., ser.*

C, (493), p. 1–140, pls. 1–19, text-figs. 1–41, table 1.

Colom, G., 1954, Estudio de las Biozonas con Foraminiferos del Terciario de Alicante. *Inst. Geol. Min., Espana. Bol,.*, 66, p. 1–279, pls. 1–35, text-figs. 1–16.

Crespin, I., 1952, Foraminiferal Zones in the Tertiary of Australia. *Geol. Mag.*, 89(3), p. 225–228.

Cushman, J. A., 1941, The species described as *Globigerina* by d'Orbigny in 1826, *Cushman Lab. Foram, Res., Contr.*, 17 (2), p. 38–42, pl. 11.

————, 1948, The Species of *Globigerina* described between 1839–1850. *Ibid.*, 22 (1), p. 15–21, pls. 3, 4.

Cushman, J. A. and Bermudez, P. J., 1937, Further new species of Foraminifera from the Eocene of Cuba. *Cushman Lab. Foram. Res., Contr*, 13 (1), p. 1–29, pls. 1, 2.

Cushman, J. A. and Renz, H. H. 1947, The Foraminiferal fauna of the Oligocene St. Croix Formation of Trinidad, B.W.I., *Cushman Lab. Foram. Res., Spec. Publ.* (22), p. 1–46, pls. 1–8.

Cushman, J. A. and Stainforth, R. M., 1945, The Foraminifera of the Cipero Marl Formation of Trinidad. B. W. U., *Ibid.*, (14), p. 1–75, pls. 1–16.

Drooger, C. W., 1954, The Oligocene-Miocene boundary on both sides of the Atlantic. *Geol. Mag.*, 41 (6), p. 514–518.

————, 1956, Transatlantic correlation of the Oligo-Miocene by means of Foraminifera. *Micropal.*, 2 (2), p. 183–192, pl. 1.

Drooger, C. W. and Batjes, D. A. J., 1959, Planktonic Foraminifera in the Oligocene and Miocene of the North Sea Basin. *Kon, Nederl. Akad. Wetenschap., ser. B*, 62 (3), p. 172–186, pl. 1, text-fig. 1.

Drooger, C. W. and Magne, J., 1959, Miogypsinids and planktonic Foraminifera of the Algerian Oligocene and Miocene. *Micropal.*, 5 (3), p. 273–284, pls. 1–2, text-figs. 1–4.

Eames, F. E., 1953, The Miocene-Oligocene boundary and the use of the term Aquitanian. *Geol. Mag.*, 40(6), p. 388–392.

————, 1954, The Caribbean "Oligocene". *Geol. Mag.*, 41 (4), p. 326–327.

————, 1955, The Miocene-Oligocene boundary in the Caribbean region. *Geol. Mag.*, 42 (1), p. 86.

Eames, F. E. and Clarke, W. J., 1957, The age of some Miocene and Oligocene Foraminifera. *Miocropal.*, 3 (1), p. 80.

Ellis, B. F. and Messina, A. R., 1940 et seq., Catalogue of Foraminifera. Amer. Mus. Nat. Hist., New York, Spec. Publ.

Emiliani, C., 1954, The Oligocene microfaunas of the central part of the Northern Appenines. *Paleontografica Ital.*, 48 (*n. s.*, 18), p. 77–184, pls. 21–25, text-figs. 1–3.

Finlay, H. J., 1939, New Zealand Foraminifera: Key species in stratigraphy-No. 2., *Roy. Soc. New Zealand*, 69 (1), p. 89-128, pls. 11-14.

Glaessner, M. F., 1953, Time-stratigraphy and the Miocene Epoch. *Bull. Geol. Soc. America*, 64, p. 647–658.

Grimsdale, T. F., 1951, Correlation, age, determination and the Tertiary pelagic Foraminifera. *3rd World Petr. Congr. (The Hague)., Proc., sec. 1*, p. 463–475, text-fig. 1.

Hamilton, E. L. and Rex. R. W., 1959, Lower Eocene phosphatized *Globigerina* Ooze from Sylvania Guyot. *U. S. Geol. Surv., Prof. Pap.*, 260–W, p. 785–798, pls. 250–254.

Hatae, N., 1960, The geology and the geological structure of Amakusa-Shimo-shima, Kumamoto Prefecture (in Japanese), *Kagoshima Univ., Sci. Rep.*, no. 9, p. 61–107, text-figs. 1–45.

————, 1960, On the *Nummulites* Zone of the Islands of Amakusa, Kyushu, Japan (in Japanese). *Tohoku Univ., Sci. Rep., 2nd ser. (Geol.), Spec. Vol.*, 4, p. 411–423, text-figs. 1–26.

Hedberg, H. D., 1937, Foraminifera of the middle Tertiary Carapita formation of northeastern Venezuela, *Jour. Paleont.*, 11 (8), p. 661–697, pls. 90–92.

Hofker, J., 1956, Foraminifera Dentata, Foraminifera of Santa Curz and Thatch-Island, Virginia Archipelago, West Indies. Skrifter udgivet af Univ. Zool. Mus., Kobenhavn, XV, Copenhagen, p. 9–237, pls. 1–35, text-figs. 1–21.

————, 1956, The structure of *Globorotalia. Micropal.*, 2 (4), p. 371–373, text-figs. 1–7.

————, 1959, On the Splitting of *Globigerina. Cushman Found. Foram. Res., Contr.*. 10(1), p. 1–9, text-figs. 1–25.

Hornibrook, N. B. De, 1957, New Zealand Upper Cretaceous and Tertiary Foraminiferal Zones and Some overseas correlations. *Micropal.*, 4 (1), p. 25–38, pl. 1, tables 1–2.

————, 1958, New Zealand Foraminifera: Key species in stratigraphy, No. 6, *New Zealand Geol. Geophys, Jour.*, 1 (4), p. 653–676, text-figs. 1–36.

Jenkins, D. G., 1960, Planktonic Foraminifera from the Lakes Entrance Oil Shaft, Victoria, Australia. *Micropal.*, 6 (4), p. 345–371, pls. 1–5, text-figs. 1–10.

Kleinpell, R. M., 1938, Miocene stratigraphy of California. Amer. Assoc. Petr. Geol., Spec. Publ., p. 1–450, pls. 1–17.

Kugler, H. G., 1954, The Miocene-Oligocene boundary in the Caribbean region. *Geol. Mag.*, 41 (5), p. 410–414.

LeRoy, L. W., 1944, Miocene Foraminifera from Sumatra and Java. *Colorado School Mines, Quart.*, 37 (3), p. 7–113, pls. 1–8 and 1–7.

————, 1953, Biostratigraphy of the Maqfi Section, Egypt. *Geol. Soc. America, Mem.*, (54), p. 1–73, pls. 1-14, text-figs. 1–4, table 1.

Mallory, V. S., 1959, Lower Tertiary biostratigraphy of the California Coast Rages. *Amer. Assoc. Petr. Geol.*, p. 1–416, pls. 1–42, text-figs. 1–7, tables 1–19.

Martin, L. T., 1943, Eocene Foraminifera from the Type Lado Formation, Fresno County, California. *Stanford Univ. Publ., Univ. Ser., Geol. Sci.*, 3 (3), p. 93–125, pls. 5–9.

Murata, S., 1960 (MS), Paleogene microbiostratigraphy of North Kyushu, Japan, Doctor Thesis, p. 1–247, pls. 1–9.

Nagao, T., 1927, Paleogene coal-bearing Formations of the Islands of Kyushu. *Tohoku Imp. Univ., Sci. Rep., 2nd Ser (Geol.)*., 11 (1), p. 1–21, text-fig. 1, table 1.

————, 1928, A summary of the paleogene stratigraphy of Kyushu, Japan, with some accounts on the fossiliferous zones. *Ibid.*, 12 (1), p. 1–10, pl. A.

Nagappa, Y., 1959, Foraminiferal biostratigraphy of the Cretaceous-Eocene succession in the India-Pakistan-Burma Region. *Micropal.*, 5 (2), p. 145–192, pls. 1–11, tables 1–9, charts 1–4.

Nakkady, S. E., 1959, Biostratigraphy of the Um Elghanyem Section, Egypt. *Micropal.*, 5(6), p. 453–472, pls. 1–7, chart 1.

Plummer, H. J., 1927, Foraminifera of the Midway Formation in Texas. *Texas Univ., Bull.* (2644), p. 1–206, pls. 1–15.

Renz, H. H., 1948, Stratigraphy and fauna of the Agua Salada Group, State of Falcon, Venezuela. *Geol. Soc. America, Mem.*, (32), p. 1–219, pls. 1–12.

Reyment, R. A., 1960, Notes on some Globigerinidae, Globotruncanidae and Globorotaliidae from the Upper Cretaceous and Lower Tertiary of Western Nigeria. *Nigeria, Rec., Geol. Surv.*, p. 68–86, pls. 15, 16.

Said, R., 1960, Planktonic Foraminifera from the Thebes Formation, Luxor, Egypt. *Micropal.*, 6(3), p. 277–286, pl. 1, text-fig. 1, tables 1–2.

Said, R. and Kenaway, A., 1956, Upper Cretaceous and Lower Tertiary Foraminifera from Northern Sinai, Egypt. *Micropal.*, 2 (2), p. 105–174, pls. 1–7.

Saito, R., 1957, Pre-Kishima (Pre-Aquitanian) crustal deformation of Japan and the adjacent circum Pacific regions. *Kumamoto Jour. Sci., ser. B. sec. 1, Geol.*, 2 (2), p. 33–50.

Schifflet, E., 1948, Eocene stratigraphy and Foraminifera of the Aquia Formation. *Maryland Dept. Geol., Mines and Waters Res., Bull.* (3) p. 1-93, pls. 1–5.

Smith, B. Y., 1957, Lower Tertiary Foraminifera from Contra Costa County, California, *Univ. Calif. Publ., Geol. Sci.*, 32(3), p. 127–242, pls. 17–32, text-figs. 1–5.

Stainforth, R. M., 1948, Applied micropaleontology in Coastal Ecuador. *Jour. Pal.*, p. 22 (2), 113–151, pls. 24–26.

————, 1948, Description, correlation and paleo-ecology of Tertiary Cipero Marl Formation, Trinidad, B. W. I., *Amer. Assoc. Petr. Geol., Bull.*, 32, p. 1292–1330, text-figs. 1–2.

————, 1953, The basis of Paleogene correlation of Middle America. *Soc. Geol. Peru, Bol.*, 26, p. 247–262.

————, 1960, Current status of Transatlantic Oligo-Miocene correlation by means of planktonic Foraminifera. *Rev. Micropal.*, 2 (4), p. 219–230.

Todd, R., 1957, Geology of Saipan, Mariana Islands, smaller Foraminifera. *U. S. Geol. Surv., Prof. Pap.* 280–H, p. 265–320, pls. 64–93, tables 1–4, map 1.

Weiss, L., 1955, Planktonic Index Foraminifera of Northwestern Peru. *Micropal.*, 1 (4), p. 301–319, pls. 1–3, text-fig. 1, tables and chart 1–2.

Explanation of Plate 19

Figs. 1a, b : *Globigerina boweri* Bolli ×75
1 km west of Kanyama, Kawaura-machi, Shimo-jima; Kyoragi formation; IGPS coll. cat. no. 77224.

Figs. 2a, b, c : *Globorotalia* (?) sp. ×70
1 km west of Kanyama, Kawaura-machi, Shimo-jima; Kyoragi formation; IGPS coll. cat. no. 77238.

Figs. 3a, b, c : *Globorotalia centralis* Cushman and Bermudez ×70
1 km west of Kanyama, Kawaura-machi, Shimo-jima; Kyoragi formation; IGPS coll. cat. no. 77233.

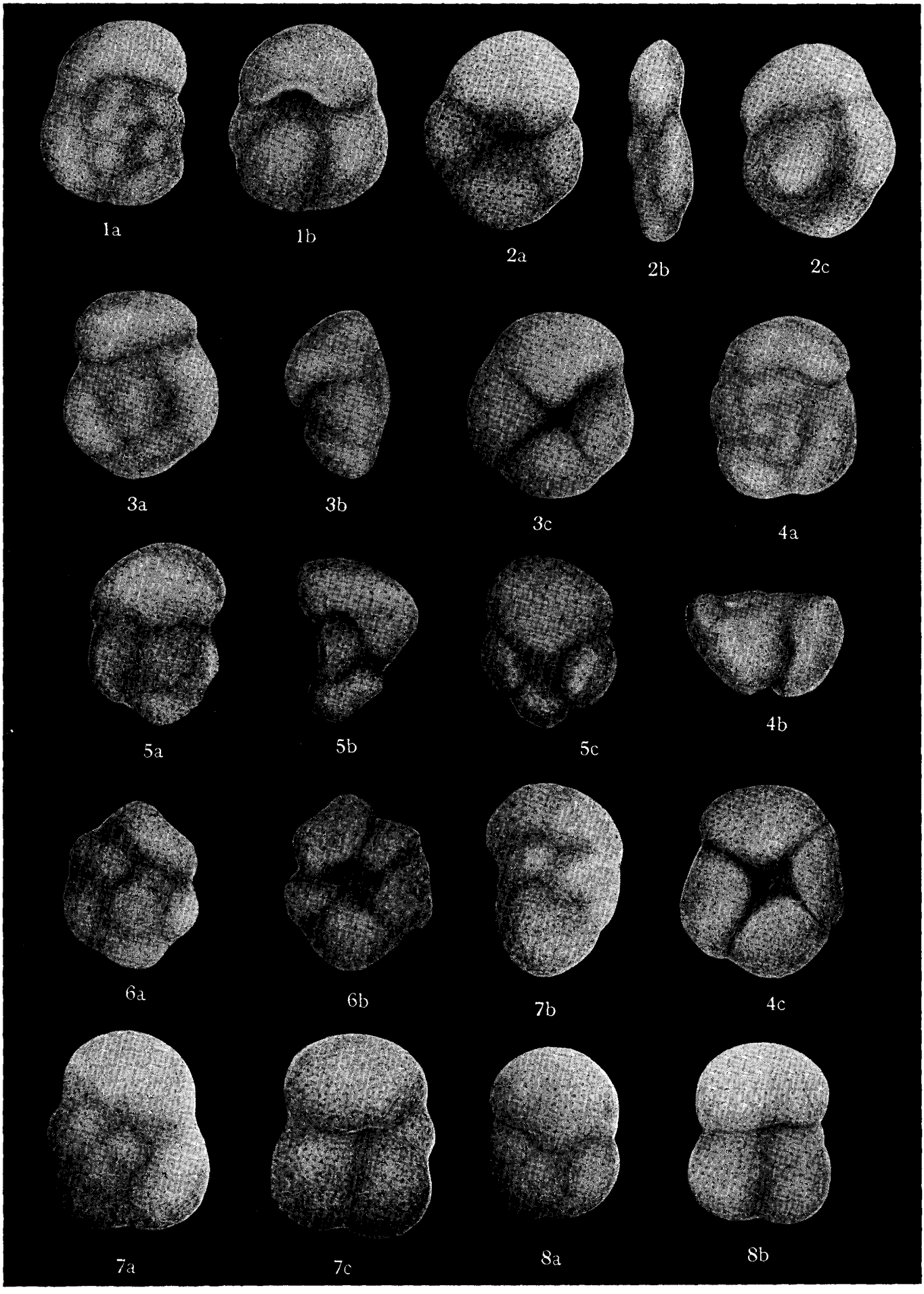
Figs. 4a, b, c : *Globorotalia bonairensis* Pijpers ×70
1 km west of Kanyama, Kawaura-machi, Shimo-jima; Kyoragi formation; IGPS coll. cat. no. 77234.

Figs. 5a, b, c : *Globorotalia bullbrooki* Bolli ×70
1 km west of Kanyama, Kawaura-machi, Shimo-jima; Kyoragi formation; IGPS coll. cat. no. 77235.

Figs. 6a, b : *Globorotalia spinuloinflata* (Bandy) ×70
1 km west of Kanyama, Kawaura-machi, Shimo-jima; Kyoragi formation; IGPS coll. cat. no. 77236.

Figs. 7a, b, c : *Globigerina linaperta* Finlay ×75
500 m west of Okubo, Ariake-mura, Kami-shima; Kyoragi formation; IGPS call. cat, no. 77227.

Figs. 8a, b : *Globigerina linaperta* Finlay ×75
1 km west of Kanyama, Kawaura-machi, Shimo-jima; Kyoragi formation; IGPS coll. cat. no. 77228.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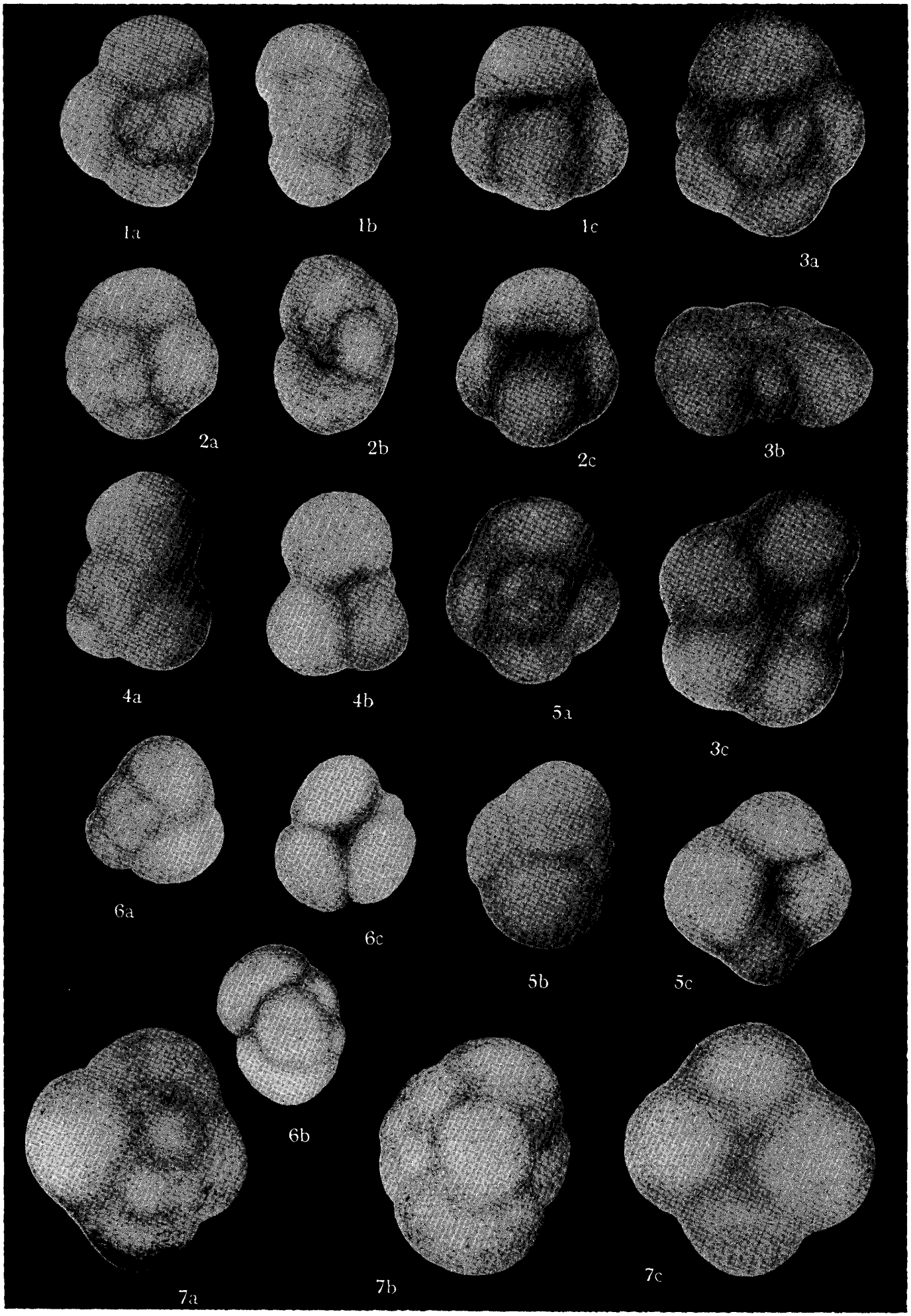
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Explanation of Plate 20

Figs. 1a, b, c; 2a, b, c: *Globigerina kyushuensis* Asano ×75
1 km west of Kanyama, Kawaura-machi, Shimo-jima; Kyoragi formation; IGPS coll. cat. no. 77226.

Figs. 3a, b, c: : *Globorotalia* cf. *pseudomayeri* Bolli ×70
500 m west of Okubo, Ariake-mura, Kami-shima; Kyoragi formation; IGPS coll. cat. no. 77237.

Figs. 4a, b : *Globigerina* cf. *trilocularis* d'Orbigny ×75
1 km west of Kanyama, Kawaura-machi, Shimo-jima; Kyoragi formation; IGPS coll. cat. no. 77231.

Figs. 5a, b, c; 7a, b, c : *Globigerina ariakensis* Asano, n. sp. ×70
Holotype (figs. 7a-c), 500 m west of Okubo, Ariake-mura, Kami-shima; Kyoragi formation; IGPS coll. cat. no. 77223.

Figs. 6a, b, c : *Globoquadrina venezuelana* (Hedberg) ×70
1 km west of Kanyama, Kawaura-machi, Shimo-jima; Kyoragi formation; IGPS coll. cat, no. 77239.

Explanation of Plate 21

Figs. 1a, b : *Globigerina linaperta* Finlay ×70
Oshima, Gowa-machi, Shimo-jima; Oniike formation ; IGPS coll. cat. no. 77252.

Figs. 2a, b : *Globigerina* sp. (*G.* cf. *yeguaensis* Weinzierl and Applin) ×75
1 km east of Kyoragi, Matsushima-machi, Kami-shima; Kyoragi formation; IGPS coll. cat. no. 77232.

Figs. 3a, b : *Globigerapsis* cf. *kugleri* Bolli, Loeblich, and Tappan ×75
About 500 m west of Hikisaka, Gowa-machi, Shimo-jima; Oniike formation; IGPS coll. cat. no. 77240.

Figs. 4a, b : *Globigerina ampliapertura* Bolli ×70
About 500 m west of Hikisaka, Gowa-machi, Shimo-jima; Oniike formation; IGPS coll. cat. no. 77222.

Figs. 5a, b : *Globigerina ouachitaensis senilis* Bandy ×70
Oshima, Gowa-machi, Shimo-jima; Oniike formation; IGPS coll. cat. no. 77229.

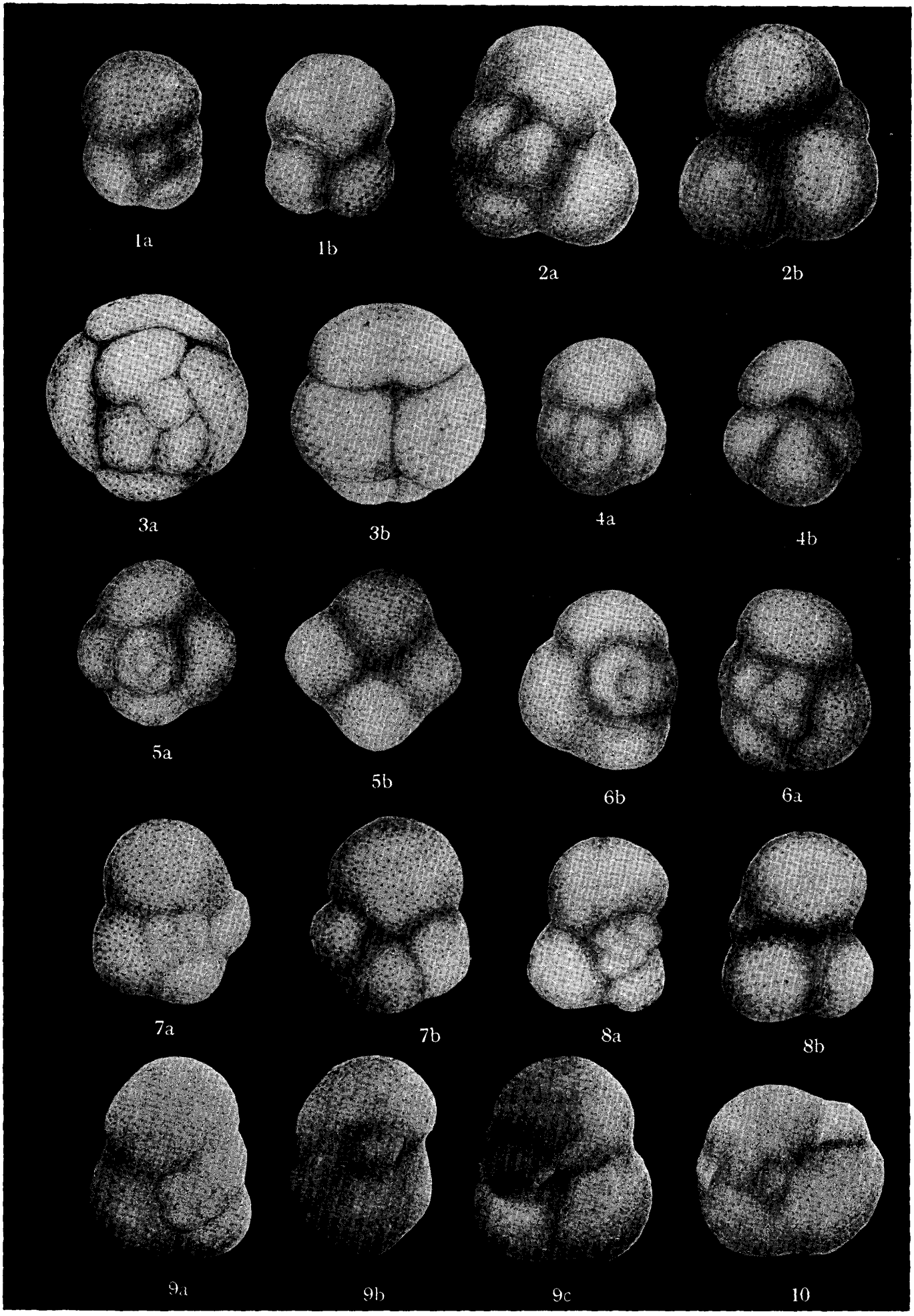
Figs. 6a, b : *Globigerina* cf. *pera* Todd ×70
Oshima, Gowa-machi, Shimo-jima; Oniike formation; IGPS coll. cat. no. 77230,

Figs. 7a, b : *Globigerina* sp. ×70
Oshima, Gowa-machi, Shimo-jima; Oniike formation

Figs. 8a, b : *Globigerina* cf. *linaperta* Finlay ×70
Oshima, Gowa-machi, Shimo-jima; Oniike formation

Figs. 9a, b, c : *Globigerina isahayensis* Asano, n. sp. ×70
Holotyp, 80 m depth of the boring core at Kamihara, Enoura-mura, Kita-takaki-gun, Nagasaki Prefecture; Enoura formation; IGPS coll. cat. no. 77225.

Fig. 10 : *Globigerinatheka* sp. ×70
1 km northwest of Yamaura, Ariake-mura, Kami-shima; Kyoragi formation; IGPS coll. cat. no. 77241.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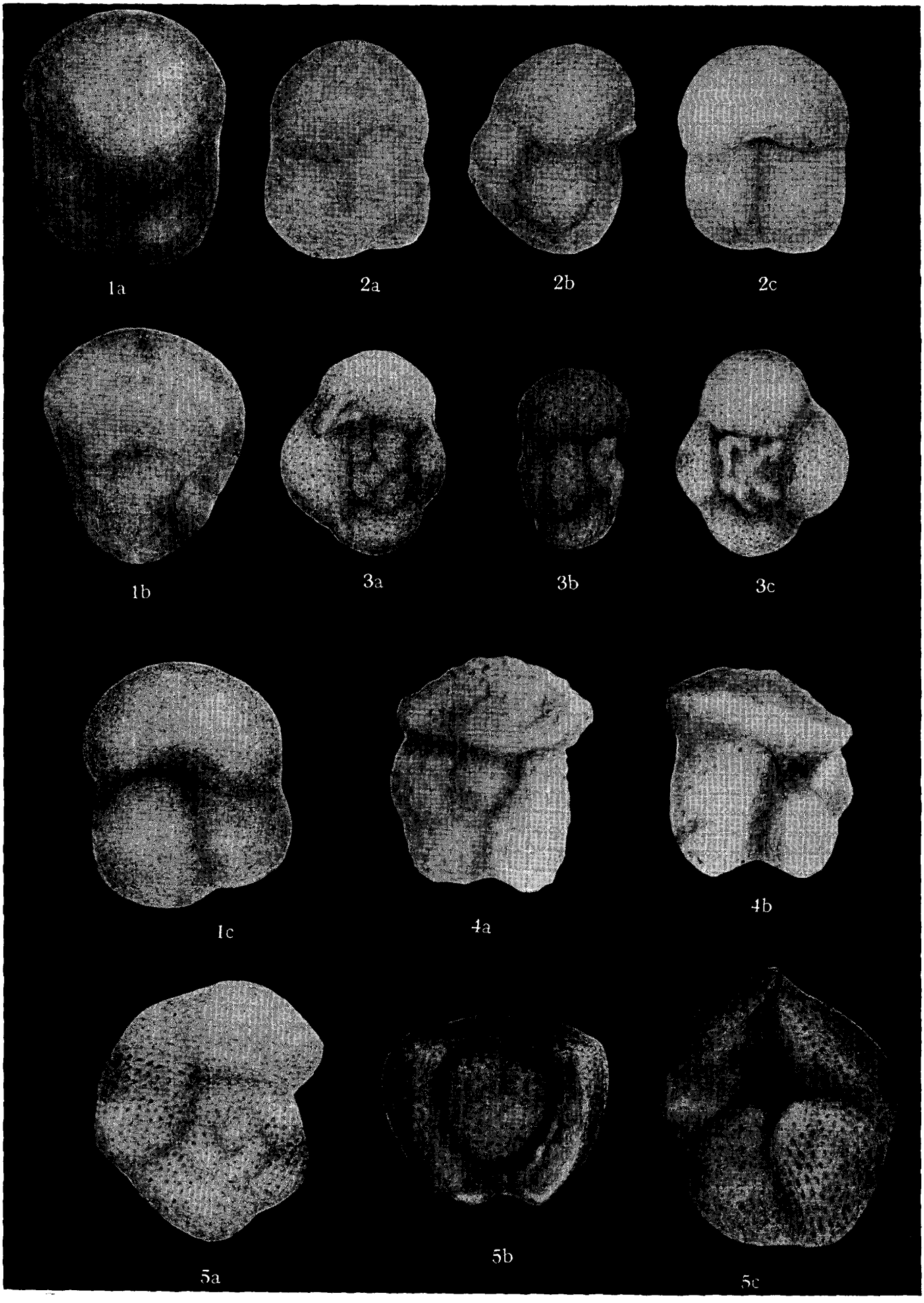
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Explanation of Plate 22

Figs. 1a, b, c : *Globigerina sakitoensis* Asano, n. sp. ×70
Holotype, Nakado, Sakito-machi, Nishisonogi-gun, Nagasaki Prefecture; Nakado formation; IGPS coll. cat. no. 77243.

Figs. 2a, b, c : *Globigerina* cf. *sakitoensis* Asano, n. sp. ×70
Yamaguchi, Kazusa-machi, Minami-takaki-gun, Nagasaki Prefecture; (formation unnamed)

Figs. 3a, b, c : *Catapsydrax dissimilis* (Cushman and Bermudez) ×70
580 m depth of the boring core at Takase, Imari City; Kishima formation (below the Arita fossil beds); IGPS coll. cat. no. 77244.

Figs. 4a, b : *Globoquadrina dehiscens* (Chapman, Parr, and Collins) ×70
West sea-cliff (Dezaki) of Okino-shima; Iojima formation; IGPS coll. cat. no. 77245.

Figs. 5a, b, c : *Globoquadrina dehiscens advena* Bermudez ×70
580 m depth of the boring core at Takase, Imari City; Kishima formation (below the Arita fossil beds); IGPS coll. cat. no. 77246.

Explanation of Plate 23

Figs. 1a, b : *Globigerinoides subquadratus* Bronnimann ×70
555 m depth of the boring core at Takase, Imari City; Kishima formation (below the Arita fossil beds); IGPS coll. cat. no. 77249.

Figs. 2a, b : *Globigerinoides immaturus* LeRoy ×70
575 m depth of the boring core at Takase, Imari City; Kishima formation (below the Arita fossil beds); IGPS coll. cat. no. 77247.

Figs. 3a, b : *Globigerina angustiumbilicata* Bolli ×70
555 m depth of the boring core at Takase, Imari City; Kishima formation (below the Arita fossil beds); IGPS coll. cat. no. 77242.

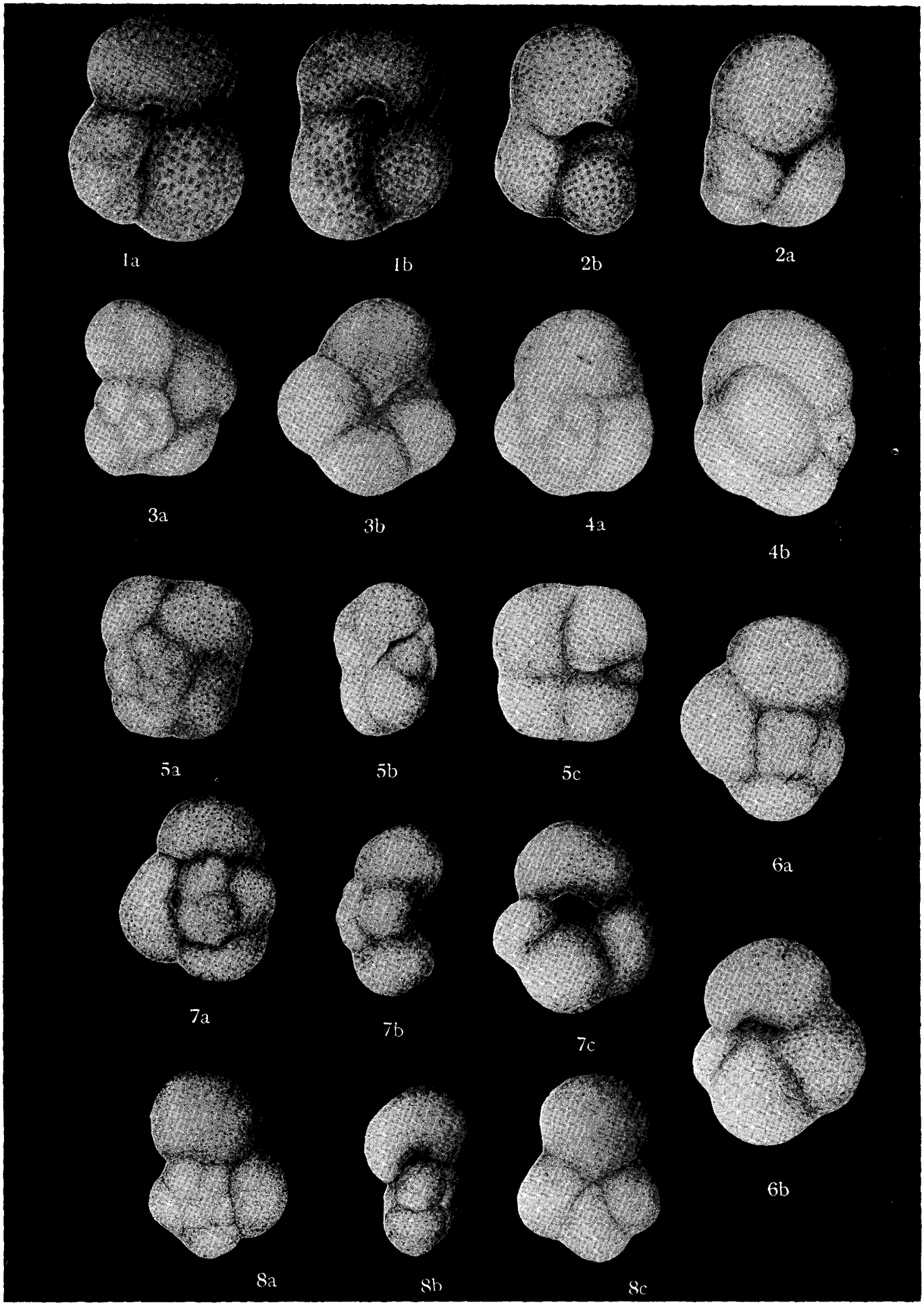
Figs. 4a, b : *Catapsydrax dissimilis* (Cushman and Bermudez) ×70
555 m depth of the boring core at Takase, Imari City; Kishima formation (below the Arita fossil beds); IGPS coll. cat. no. 77244,

Figs. 5a, b, c : *Globorotalia opima nana* Bolli ×70
220 m depth of the boring core at Amasumi, Wakamatsu City; Norimatsu shale; IGPS coll. cat. no. 77250.

Figs. 6a, b : *Globigerina* cf. *trilocularis* d'Orbigny ×70
90 m depth of the boring core at Shimuta, Wakamatsu City; Norimatsu shale

Figs. 7a, b, c : *Globigerinoides muratae* Asano, n. sp. ×70
Holotype, 80 m depth of the boring core at Shimuta, Wakamatsu City ; Norimatsu shale; IGPS coll. cat. no. 77248.

Figs. 8a, b, c: *Globorotaloides suteri* Bolli ×70
80 m depth of the boring core at Shimuta, Wakamatsu City; Norimatsu shale; IGPS coll. cat. no. 77251.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